Construction Analysis for Pavement Rehabilitation Strategies

Software Development

The Caltrans Division of Research and Innovation funded the *CA4PRS* concept development. The State Pavement Technology Consortium (SPTC), a pooled-fund project,[1] SPR-3(098), comprised of Caltrans, Minnesota DOT, Texas DOT and Washington State DOT, funded the development of the *CA4PRS* software program.

Future Enhancements to *CA4PRS*

Within the next year, additional modifications to the software will include:

- Additional rehabilitation treatments (dowel bar retrofit, hot-mix asphalt overlays, hot-mix asphalt mill and fill, etc.)
- Option to evaluate continuously reinforced concrete pavements
- Additional materials (hot-mix asphalt base, cement treated base, aggregate base, etc.)
- Ability to evaluate more than just a divided four lane facility

For More Information

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Price Information (per License)

- **Education: $750**
- **Government: $950**
- **Commercial: $3,000**

On the web:
http://www.dot.ca.gov/research/roadway/ca4prs/ca4prs.htm

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[1] "The Federal Highway Administration (FHWA) sponsors the Transportation Pooled Fund Program as a means for interested States, FHWA, and other organizations to partner when significant or widespread interest is shown in solving transportation-related problems. Partners may pool funds and other resources to solve these problems through research, planning, and technology transfer activities." (http://www.tfhrc.gov/site/active.htm)

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The Problem

For the rehabilitation of freeways with large traffic volumes, it is desireable to design and construct a pavement section that provides a long life (at least 50 years) and minimizes future traffic delays due to maintenance and rehabilitation activities. However, on heavily trafficked freeways, limitations are often placed on construction closures due to traffic delay concerns. The challenge becomes how to design, analyze and construct long-lived pavements while minimizing traffic delays.

Washington State Department of Transportation

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One Solution

Construction Analysis for Pavement Rehabilitation Strategies (*CA4PRS*) estimates the amount of highway pavement that can be rehabilitated under various project constraints. The software provides a construction schedule baseline for the pavement design, construction logistics and traffic operations. It was designed to help agencies and paving contractors develop construction schedules that minimize traffic delay and agency costs.

CA4PRS considers what-if scenarios for major parameters and alternatives, such as:

- **Rehabilitation strategy:** Portland cement concrete reconstruction, concrete crack and seat and hot-mix asphalt overlay or full-depth hot-mix asphalt replacement.
- **Construction window:** nighttime closures, weekend/weekday closure, continuous closure (roadway closed for extended period of time until construction is completed) or combinations of the above.
- **Lane closure tactic**: number of lanes to be closed for rehabilitation (i.e., one lane or all lanes).
- **Material selection**: mix design and curing time for concrete or cooling time for hot-mix asphalt.
- **Pavement cross section:** thickness of new concrete or hot-mix asphalt.
- **Pavement base type:** lean concrete base or hot-mix asphalt base.
- **Contractor's logistical resource:** location, capacity and number of available equipment (batch plant, delivery trucks, haul trucks and paving machine).
- **Scheduling interface:** mobilization and demobilization, traffic control time, activity lead-lag time relationships and buffer sizes.

CA4PRS can be incorporated with traffic simulation models or even simple Highway Capacity Manual calculations, to maximize on-schedule construction production and minimize costs for the agency and road users (delay costs) during roadway construction.

Construction Scenario's

At this time, *CA4PRS* can analyze two construction scenarios for a roadway section on a four lane divided roadway. One of these scenarios is sequential construction **(Figures 1 and 2)**. In sequential construction, one construction process (i.e., pavement removal) is completed over the roadway length prior to next step (i.e., roadway grading) is begun.

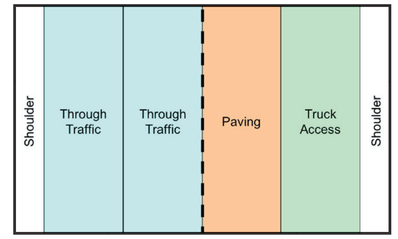


Figure 1. Sequential Construction - Reconstruction of One Lane

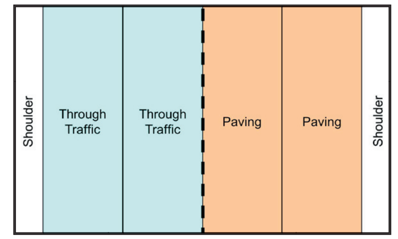


Figure 2. Sequential Construction - Reconstruction of Two Lanes

The other construction scenario is concurrent construction **(Figures 3 and 4)**. In concurrent construction, one process is begun (i.e., pavement removal) and as soon as there is sufficient distance between operations, the next process is begun (i.e., roadway grading).

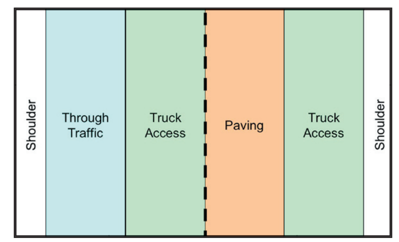


Figure 3. Concurrent Construction - Reconstruction of One Lane

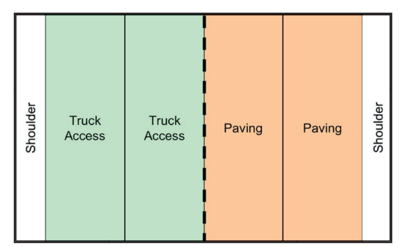


Figure 4. Concurrent Construction - Reconstruction of Two Lanes

In addition two construction sequences, *CA4PRS* can also analyze a continuous roadway closure with continuous roadway construction (roadway closed 24 hours per day with construction occurring 24 hours per day) or a continuous roadway closure with a shift operation (i.e., roadway closed 24 hours per day with construction occurring 10 hour days).

Who Could Use *CA4PRS?*

CA4PRS is useful to many sectors of the transportation industry: state highway agencies, especially during the planning and design stages when the information can be used to optimize pavement, construction and traffic scenarios, design engineers, construction engineers, consultants and paving contractors during estimating and project control stages.

CA4PRS is a decision-making tool for design, construction, and traffic engineers to select the best construction schedules that cause minimum traffic delays during highway rehabilitation and reconstruction projects.

CA4PRS Use and Validation

CA4PRS has been successfully applied to several urban freeway rehabilitation projects with heavy traffic volumes in California, including I-10 in Pomona, I-710 in Long Beach and I-15 in Devore reconstruction projects. Caltrans is in the process of using this tool on two additional projects on I-15 in Ontario and on I-710 in Compton. The software has also been used to determine the number of needed weekend closures for pavement reconstruct on I-5 James to Olive (Convention Center vicinity) and I-5 in the Federal Way vicinity of Washington State and on the I-494 pavement reconstruction in St. Paul, Minnesota. WSDOT has reached the point where major rehabilitation and reconstruction is needed on over 400 lane miles of heavily trafficked urban concrete pavement. This challenge becomes greater due to the impact major rehabilitation and reconstruction will have on the traveling public. Long delays and long construction periods are potentially detrimental to pavement quality as well as dramatic increase in user frustrations and higher costs. Therefore, WSDOT will utilize the *CA4PRS* software to help determine the number of lane miles that can be rehabilitated or reconstructed in as short a time period as possible or how aid in choosing which type of roadway closure is best suited for the given type of work.

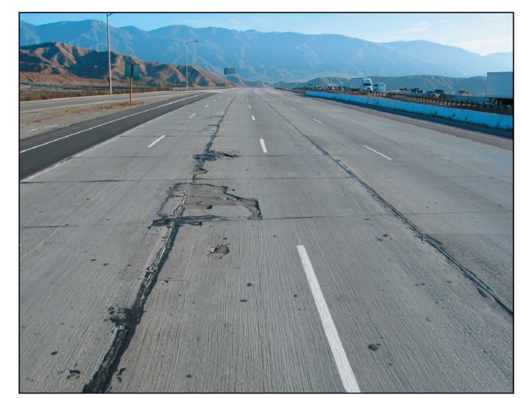
CA4PRS Results

The *CA4PRS* software estimates how much pavement can be rehabilitated or reconstructed under different traffic closure strategies, considering project design, project constraints and the number of lanes closed.

For demonstration purposes, the California I-15 reconstruction project will be described to illustrate the benefit of the *CA4PRS* results. It is important to note that I-15 is the major link between Los Angeles and Las Vegas. Because of this, weekend traffic is significantly higher than weekday traffic. Therefore, Caltrans determined that a weekend closure for this reconstruction project would have too great an impact on roadway users and was therefore determined to not be an option.

Table 1 illustrates the results of the California I-15 Devore project. The analysis results indicated that the continuous closure of all lanes in one direction results in the fewest road closures, the lowest total cost (includes user cost, construction cost and traffic handling cost), but the maximum peak delay. It is also interesting to note that the "typical" urban roadway construction scenario, 10-hour night-time closure, results in the highest number of closure hours, the second highest total cost, and the fewest minutes of maximum peak delay. When offered the choice, the commuters preferred the continuous closure of all lanes in one direction, since it spread the closure over both commuter and Las Vegas – bound traffic and would be done in just two closure events. The continuous closures were a success, as was the entire project.

Prepared with this type of information, an agency can more quantitatively estimate how to maximize on-schedule construction production and minimize costs for the agency and the road user.



Typical Distress on I-15 Devore

Traffic during Construction (one direction closed, traffic crossed over to other direction)

Placement of Concrete Pavement

Table 1. *CA4PRS* Results for California I-15 Devore Project

Construction Scenario	Schedule Comparison		Cost Comparison ($M)			Maximum Peak Delay (min)
	Total Closure	Closure Hours	User Delay	Construction Cost	Total Cost	
Continuous closure all lanes one direction[1]	2	400	6.9	9.9	16.8	195
72-hour continuous weekday closure[2]	8	512	5.6	12.6	18.2	75
55-hour continuous weekend closure[3]	10	550	14.2	15.1	29.3	195
10-hour night-time closure[4]	220	2,200	4.9	20.4	25.3	35

1. Roadway closed 24 hours a day for a continuous 400 hour (approximately 17 days) period
2. Roadway closed for 72 continuous hours on eight separate occasions (though eight 72 hour closures result in a total of 576 hours, this does not result in a whole number (512 hours + 72 hour closure = 7.11 closures), therefore, the program rounds up to the next whole number
3. Roadway closed for a 55 continuous hour period on ten separate occasions
4. Roadway closed each night for 10 hours requiring a total of 220 closures